If newly prepared, or, rather, if liquid paint is used, the spirit is liable to wash up some of the paint and some of the oil, in extremely minute globules, which will dim the preparation, and make it appear like glass that is breathed on. If the spirit is diluted with water as much as its preserving powers will bear, its action on the paint will be almost destroyed, and the preparation remain bright.

Having mentioned the public-spirited patronage given to microscopic improvements by Dr. Goring, it is but just to add the name of R. H. Solly, Esq., whose liberal patronage in the same cause has mainly fostered these microscopic communications to the Society, and brought them much more fully before the public than otherwise they would have been.

I am, &c. &c.

A. Aikin, Esq. CORNELIUS VARLEY.
Secretary, &c. &c.

SUPPLEMENT.

Letter from R. H. Solly, Esq. on certain Parts of Vegetable Structure.

SIR,

HAVING acceded to Mr. Cornelius Varley's request to have a botanical drawing he made for me engraved, for the purpose of illustrating his paper on the microscope, it may, perhaps, not be uninteresting to the Society if I add some observations to the description of the drawing already given by Mr. Varley in his communication.

Fig. 51, Plate V., represents one of the petals of the corolla of the *anagallis arvensis,* or common scarlet pimpernel, of its natural size. Fig. 52 is the same, magnified twenty-one times, and around it are some of the joints and terminations, shewn separate, and magnified three hundred times; the same letters referring to the same parts in both cases. As the corolla of the *anagallis* is said to be monopetalous, one of the petals (of the corolla of the *anagallis*) may perhaps be considered an inaccurate expression; but as I believe that botanists now all agree that what is called a monopetalous corolla is really a corolla of several petals, usually three or five united together by their edges, I have used the expression, one of the petals, instead of one of the segments of the corolla; and I think the direction of the veins, as represented in fig. 52, Plate V., clearly shews that it is a complete petal or leaf. I the more readily consented to Mr. Varley's request to have this drawing engraved, because I am not aware that any drawing has been previously engraved, shewing clearly not only all the veins of a petal, but also the method in which they are constructed; and though this engraving represents only the petal of the *anagallis* or pimpernel, yet the petals of the common chickweed, and, I believe, those of all flowers having a small and delicate corolla, are constructed in a similar manner. The construction of the veins is seen rather more easily in the petal of the common chickweed than in that of the pimpernel, in consequence of the petal of the chickweed not being coloured. I think it is but justice to Mr. Gill, one of our late chairmen of the Committee of Mechanics, to state that he first called my attention to the flower of the pimpernel as a beautiful microscopic object.

The veins in the petal of the *anagallis* are composed

entirely of spiral vessels. As many of our members are but little acquainted with vegetable anatomy, it may perhaps be proper here to explain what a spiral vessel really is. A spiral vessel consists of a very fine transparent membrane forming a cylindrical tube, closed at each end by a conical termination, and having one or more fine threads wound in a spiral direction round the inside of the tube: I think that these fine threads are themselves tubes, though that has been disputed, and they are so fine that it will require very nice observation to settle the point. The thread adheres so firmly to the tube, that, in unwinding or pulling it out, the tube is torn in a spiral direction between each coil of the thread, so that it has been doubted if there were a complete tube, independent of the spiral thread; or whether the membrane only connects the spiral coils of the thread, which really is much the same thing. By an inspection of fig. 52, Plate V., it will be evident that, although the veins run in an uninterrupted line from the base of the leaf to very near the margin, yet that the spiral vessels of which they are composed are individually short compared with the length of the vein, each vein being composed of many spiral vessels; and where one spiral vessel terminates and another begins, the ends which are contiguous overlap each other, as if they were spliced together.

Although the veins ramify, yet the individual spiral vessels of which they are composed never do so, but where the veins branch the branches are formed either by one spiral vessel being spliced on to the side of another, or by two spiral vessels being spliced on to the end of a third on the opposite sides.

Some of the parts of the veins where they branch are shewn separate, on a larger scale, surrounding fig. 52,

Plate V. The corolla of the *anagallis* is entirely composed of spiral vessels and cellular tissue, enclosed in a thin membrane or cuticle. As it may be proper to give some description of cellular tissue, I cannot do better than quote that given by Mr. Lindley, in his *Outline of the First Principles of Botany*, a book I would earnestly recommend every body to read who wishes to acquire really sound botanical knowledge, as it contains a great deal of information in a very small compass.

" Cellular tissue is composed of transparent vesicles, the sides of which are not perforated by visible pores. Each vesicle is a distinct individual, cohering with the vesicles with which it is in juxta-position; therefore the apparently simple membrane that divides two contiguous cells is in fact double. The vesicles of cellular tissue, when separate, are round or oblong; when slightly and equally pressed together, they acquire an hexagonal appearance; stretched lengthwise, they become prismatical, cylindrical, or fusiform."

The oblong vesicles of cellular tissue are sometimes marked with spiral lines, in which case they seem to have some imperfect resemblance to spiral vessels. Ducts are said to be distinguished from spiral vessels principally by their being incapable of being unrolled; but ducts are often capable of being unrolled, though in that case they rather resemble ribands than threads. In the plates to a work by Kieser, entitled *Mémoire sur l'Organisation des Plantes*, are some very beautiful and accurate representations of ducts, some of which are partly unrolled. Spiral vessels are probably sometimes converted into ducts by the threads partially adhering together. The terminations of ducts are similar to those of spiral vessels. I believe Mr. Valentine, by dissecting

them out cleanly from the cellular tissue in which they are enveloped, was the first person who shewed clearly the terminations of spiral vessels and ducts, and the way in which their contiguous ends are joined to one another. I have got some preparations shewing this very clearly, which Mr. Valentine put up for me in spirits in the spring of 1830, according to the method described in the present volume of the Society's *Transactions,* and which still remain as perfect as they were when first put up. I believe the terminations of ducts and spiral vessels had been previously seen and described, though imperfectly, by other persons. Both ducts and spiral vessels may be beautifully seen and easily dissected out from boiled asparagus. It may perhaps tend to reconcile the contradictory opinions entertained by botanists, as to whether the sap rises through the cellular or the vascular tissue, to remark, that as ducts and spiral vessels are closed at both ends, they are in fact elongated cells. Spiral vessels are said to exist only in *phænogamous* or flowering plants, and therefore in the Natural System of Botany *phænogamous,* or flowering plants, are called *vasculares;* and *cryptogamous,* or flowerless plants, are called *cellulares;* but as Mr. Valentine found spiral vessels (though rather imperfect) in *filices* or ferns, this distinction is not quite correct. Perhaps the best arrangement would be to divide plants, as at present, into the two grand divisions of *phænogamous,* or flowering plants, and *cryptogamous,* or flowerless plants; and leaving the subdivisions of *phænogamous,* or flowering plants, the same as at present, to divide *cryptogamous* plants into two subdivisions, *vasculares* and *cellulares;* particularly as ducts exist in a large class of *cryptogamous* plants. I believe there is not at present any satisfactory account of the

use of, or the functions performed by, spiral vessels; but perhaps by attending to the particular parts of plants in which they are found, some conjecture may be formed upon the subject. Spiral vessels are said to exist only in the medullary sheath, and in the parts which emanate from it in an ascending direction, as the leaves and the flowers (which are supposed to be only modified leaves), and not in any part that is formed in a downward direction, as the wood, the bark, and the root; the wood increasing only by successive additions to its exterior surface, and the bark by successive additions to its interior surface. I think the most accurate general expression for those parts of plants in which spiral vessels exist, would be, those parts which grow by an increase through the whole of their substance, or which elongate by the general extension of parts already formed. A root is said to increase in length only by the successive addition of new matter to its apex or point, and not by any extension of a part already formed: it is also said not to contain spiral vessels; but Mr. Valentine found spiral vessels in the root of the *agapanthus umbellatus*, or blue African lily, but only near its point; and I think it probable that some roots may occasionally grow to some extent by the extension of the parts near the end, which are recently formed, and not merely by the addition of new matter at the apex. If a bulb, (or a bulbous root, as it is erroneously called), the bulb of a hyacinth for instance, be cut open in the winter, or very early in the spring, it will be found to contain within it the whole plant, small, but perfectly formed, consisting of the leaves, the stalk, the flowers, with all their parts complete; so that the subsequent growth of the plant seems to be nothing but the evolution of parts previously formed.

The hyacinth, particularly during the early period of its growth, will be found to consist principally of cellular tissue, and spiral vessels, or ringed vessels. A ringed vessel is a tube terminating in a cone at each end, in the same way that a spiral vessel does: the tube consists of a fine membrane, which is prevented from collapsing by equidistant internal rings. In different vessels these rings will be found to be at very different distances: they are sometimes so far apart that they appear to be loose in the cellular tissue; but I believe, if accurately examined, they will always be found to be enclosed in a tube. Ringed vessels have been supposed, perhaps erroneously, to be formed from spiral vessels, by the threads of the spiral vessels being broken by the stretching of the tube, and the successive coils of the threads collapsing into rings. Rings and spiral threads are often seen alternating with each other in the same vessel; they run so much into one another, that I think they may be considered merely as varieties of the same kind of vessel.

Very good specimens of rings and spiral threads alternating with each other in the same vessel, may be found in the stem of the *tradescantia virginica*, or Virginian spider-wort: ringed vessels may also be easily dissected out from the petiole, or leaf-stalk, of the common or culinary rhubarb, especially after it has been boiled. The leaves and stalks of some plants grow with astonishing rapidity: they will, on examination, be found to consist of a very small quantity of solid matter, not one-tenth or perhaps sometimes not so much as one-twentieth, the remainder being a watery fluid; and the solid matter will be found to consist principally of cellular tissue, and spiral or ringed vessels.

Suppose a person had this problem to solve,—What

would be the best way of constructing a vegetable substance so that it shall be formed completely in a small space, and be capable of rapidly developing itself into a large plant? Such a substance could not be constructed better than of cellular tissue and spiral vessels, the cells being collapsed, and the spiral threads pressed close together; then, if by any process the cells were rapidly but gradually filled with fluid, a small stalk with minute buds might, in a short time, be expanded into a lofty stem, bearing large bunches of flowers, as the *agave americana,* or American aloe, which rises to the height of twenty feet and upwards in a very few days. I do not mean to assert that the whole of this growth consists merely of the expansion of the cells by their being filled with sap, and the consequent stretching or expansion of the spiral vessels; for the sap, at the same time that it expands the tissue, becomes partly assimilated to it, and thus increases the solid matter of the stalk. Though the stem is developed, it is not formed in a very short space of time. In its own native hot country the American aloe takes some years to form its flowering stem; and in this country, I believe, it seldom blossoms till it is forty or fifty years old. That there is a great flow of sap into the flowering stem of the American aloe at the time of its developement, is proved by the method employed for procuring the liquor called *pulque,* which is the favourite beverage of the inhabitants of Mexico.* Just as the flowering stem begins to shoot up, it is cut off, and the centre of the plant is cut out so as to form

* There is a curious error in the Supplement to the *Encyclopædia Britannica,* where *pulque* is said to be procured from a species of cactus, or opuntia.

a bowl, into which the sap which was intended for the developement of the flowering stem flows, and from which a considerable quantity of liquor is procured during all the time that the plant would have remained in flower. I think it is clear that the great influx of sap is the principal cause of the rapid developement of the flowering stem; but the cause of the influx of the sap is by no means clear. Perhaps the phenomena first observed by Dutrochet, and called by him *endosmose* and *exosmose*, (to which I shall have occasion again to refer), may have something to do with it; though I do not see how they are capable of explaining it. It is said, that in a leaf there are two sets of vessels, one of which is on the upper and the other on the under side, and that they communicate with each other at or near the margin of the leaf, that the circulation is carried on by the sap ascending from the stem through the vessels on the upper side of the leaf, and returning by those on the under side. But it is clear that this cannot be the case in the corolla of the *anagallis*, and in those flowers which are similarly constructed; for, on referring to the engraving of the petal, fig. 52, Plate V., it will be seen that there is only one set of veins, and that each vein is composed of only one line of vessels, except where the vessels overlap each other for a short distance at their junctions;* the sap, therefore, cannot flow up through one set of vessels and down through another, but the circulation must be carried on in some other way, and I think probably by means of what has been called *endosmose* and *exosmose*, of which phenomena it will be necessary to give some explanation.

* This perhaps may not be clearly seen in the Engraving, but a microscopic examination of the petal of the *anagallis* will shew it very clearly.

If any two fluids, or if a solid and a fluid, having a chemical attraction for each other, are prevented from coming in contact by the intervention of any thin animal or vegetable membrane, they will pass through the membrane and unite with each other, although under ordinary circumstances the membrane would be impervious to one or both the fluids. There will always be two currents passing through the membrane in opposite directions, but the current will be the strongest from that fluid to which the membrane is the most pervious towards that to which it is the least pervious.

When a solid and a fluid are employed there will also be two currents, provided the solid is soluble in the fluid; for in case it is not, there will only be a current in one direction from the fluid to the solid: where two solutions of the same substance (as sugar for instance) are employed, but differing in strength, there will be currents through the membrane in opposite directions, but the strongest current will be from the thin syrup to the thick, and by means of these two currents the strength of the two solutions will ultimately become equal. Let us try if we can apply these phenomena to explain the way in which the sap circulates in the petal of the *anagallis.* The fluid with which the cells are filled is a mucilaginous juice; by the evaporation of the water this juice becomes thicker; but as the greatest evaporation will take place from that part of the petal which is nearest the outer edge, that part being the most exposed to the sun and air, the mucilaginous juice which is contained in the cells situated in that part of the petal will be the thickest: there will, therefore, be a current into those cells from the cells immediately adjoining them, in which the sap will be thinner; but there will also be a counter-current

from the thick sap to the thin, tending to equalise the density of the sap in these two sets of cells; and as the sap in the second set of cells will thus become thicker than that in the cells immediately adjoining them on the side farthest from the outer edge of the petal, an interchange of sap will take place between these two sets of cells: thus there will be a constant circulation of the sap going on through all the cells whenever, from evaporation or any other cause, there shall be any difference in the density of the sap contained in any of the cells. There will be two currents traversing the whole of the petal, one from the base to the outer edge, and the other from the edge to the base: the current from the base will be the strongest to supply the greater evaporation in that part of the petal which is most exposed to the sun and air. As the circulation can thus be carried on through the cellular tissue alone, it may be asked, What is the use of the spiral vessels? The spiral vessels being themselves cells, an interchange of currents will take place between them and the cells with which they are in contact, in the same way as it takes place between one cell and another; but the spiral vessels being tubes, are in contact with many of the cells, between all of which and the spiral vessel a circulation may be going on; and as there are lines of spiral vessels running all the way from the base of the petal to near its margin, the circulation can be carried on through the whole petal by means of these veins with much greater rapidity than it could by the cellular tissue alone; the lines of spiral vessels are also continued down the stalk, and thus serve to promote a similar circulation between the various parts of the flower and the footstalk on which it grows. The spiral vessels may be beautifully seen in the stamens of the

anagallis, running up the centre of the filament. Besides promoting the circulation, the veins probably tend to give stability and a determinate form to the petal, and serve to connect together the cells of the cellular tissue. I have endeavoured to point out what I conceive to be one of the causes which tend to promote the circulation of the sap, but I am well aware it cannot be the only cause; for it would act just as well upon dead vegetable matter (so long as it retained its organisation) as it would upon living. If, therefore, it were the only cause, the sap would continue to circulate in a dead plant just the same as in a living one; and in the winter (at least when there was no frost) just as well as it would in the spring and summer, which we all know not to be the case; nor will it account for the great flow of sap during the time of the rapid developement of the flowering stem of the great American aloe, and which also takes place in other plants during the developement of their leaves and branches in the spring and early part of the summer.

The laws of mechanical and chemical action to which living plants are subject, are so modified and controlled by those of vital action, that until we are better acquainted with the laws of vital action, all attempts to explain the cause of the circulation of the sap and the growth of plants must necessarily be very imperfect. Though a knowledge of the laws of mechanical and chemical action will not alone be sufficient to explain the cause of the growth of plants, still it may give us considerable help towards attaining a knowledge of that cause. For instance, although Mr. Knight's very ingenious experiment (published in the *Transactions of the Royal Society for the Year* 1806) of causing beans to

grow on a revolving wheel, did not explain the cause why the beans grew at all, that depending upon vital action; but the beans being in a state of growth, it clearly proved that the mechanical action of gravitation is the cause of the descent of the *radicle* or root, and of the ascent of the *plumula* or stem. When I began this paper I only intended to have given a short explanation of the engraving of the petal of the *anagallis*, but I find my subject has led me on to a much greater length than I was aware of. I am afraid many of the members will think that a great part of this communication is foreign to the views of this Society; but perhaps some advantage may result from that very circumstance, if it should be the means of inducing some of the members of the society to turn their attention to vegetable physiology who perhaps might never otherwise have thought about the subject; and thus, though this communication should not in itself contain much information, it may be the means of eliciting it from others. I have only to say, in conclusion, that I shall feel much obliged to any person who will point out any errors into which I may have inadvertently fallen.

I am, Sir, &c. &c.

Great Ormond Street,
Dec. 31, 1831.

R. H. SOLLY.

A. AIKIN, Esq.
Secretary, &c. &c.